near a blower that controlled temperature. Isotopic analysis of leaf tissue, which at the site of photosynthesis should be the most sensitive to isotopic shifts, showed no difference among the three UV treatments: full solar UV+PAR (photosynthetically active radiation, 400–700 nanometers), –UVB, and –UVA+UVB (second figure). Unlike the microbial mats, in which the absence of UV led to a depletion of ^{13}C relative to ^{12}C of several per mil, there was no detectable difference among plant treatments.

Isotopic discrimination in plant leaves is largest when the rate at which CO_2 is supplied to the enzyme ribulose bisphosphate carboxylase (RubisCO) exceeds the enzymatic uptake rate. Discrimination is suppressed to the extent that CO_2 fixation draws down the CO_2 concentration inside the leaves because of leaf stomatal resistance. The d ^{13}C values of the radish plants were identical under all growth conditions. This indicates that the balance between the rates of CO_2 diffusion through the leaf stomata and CO_2 fixation by RubisCO were unchanged under the three UV irradiation regimes.

In contrast, the d ^{13}C values of the microorganisms did increase with higher levels of UV exposure. This trend cannot be attributed to slower rates of photosynthesis at higher UV exposures, because d ^{13}C values would be expected to decrease with a decrease in the rate of photosynthetic CO_2 assimilation, relative to the rate of CO_2 supply to the microbes. This isotopic trend compels another interpretation that invokes changes in carbon flows elsewhere in metabolism, related perhaps to the synthesis of nucleotides, proteins, or lipids, or to respiration. If the influence of UV on isotopic discrimination in metabolism could be understood, it might allow us to delineate more precisely the metabolic effects of UV irradiation.

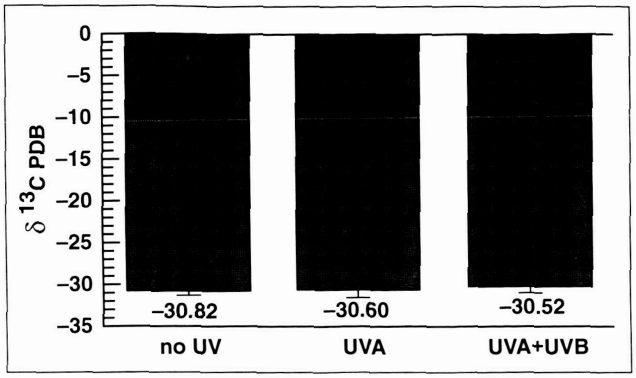

Fig. 2. Isotopic fractionation for radishes.

The conclusion is that UV can effect isotope fractionation in some, but not all photosynthetic organisms. Aruna Balakrishnan, a student, collaborated with the Ames researchers on this project.

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Perceptual Image-Compression Prototype

Andrew B. Watson

NASA missions have generated and will continue to generate immense quantities of image data. For example, the Earth Observing System is expected to generate data in excess of one terabyte per day. NASA confronts a major technical challenge in managing this great flow of imagery: in collection, preprocessing, transmission to Earth, archiving, and distribution to scientists at remote locations. Expected requirements in most of these areas clearly exceed the capabilities of current technology. Part of the solution to this problem lies in efficient image-compression techniques. As part of a larger program of human factors research, Ames has developed a new technology called DCTune to improve image compression.

For much of this imagery, the ultimate consumer is the human eye. In this case, image compression should be designed to match the visual capacities of the human observer. DCTune is based on a model of human vision, and DCTune technology is compatible with JPEG (Joint Photographic Experts Group), the current international standard for still-image compression. Two patents have been awarded for DCTune technology.

DCTune calculates the best JPEG quantization matrices to achieve the maximum possible compression for a specified perceptual error, given a particular image and a particular set of viewing conditions. In DCTune, a target perceptual error of 1.0 means that for the specified viewing conditions the compressed JPEG image is perceptually lossless; that is, it will appear exactly the same as the original uncompressed image.

DCTune offers three key benefits:

1. Accurate specification of visual quality. DCTune incorporates a scale that relates directly to perceptual quality. A value of 1 indicates perceptually lossless quality.

2. Custom quantization matrices optimized for specific applications (printing, internet, web-TV, medical imaging, TV, digital video disks, digital video camcorders, digital TV, high-definition TV, teleconferencing, etc).

3. Reduced file size. For a given level of visual quality, DCTune will produce a smaller file than standard JPEG.

To expedite transfer of this NASA technology to the commercial sector, we have developed a prototype application and made it available to potential developers. DCTune1.1 is a minimal implementation of DCTune technology that is offered free for demonstration purposes only. It takes a color image, computes the optimal quantization matrix, and generates both the matrix and the compressed image.

The figure shows an original image (left) and the same image after compression using the DCTune prototype. The amount of compression was selected so that original and compressed images would be indistinguishable.

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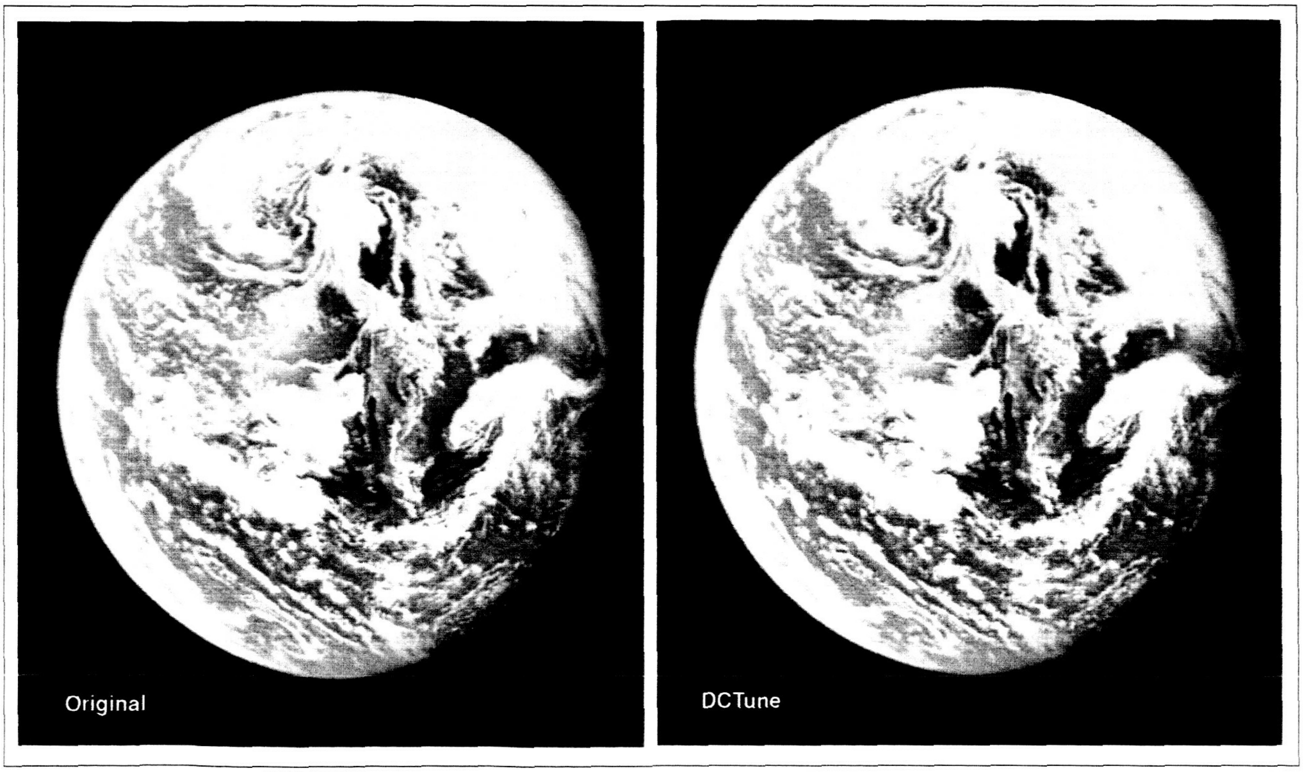

Fig. 1. An original image (on the left) and the image (on the right) resulting from application of DCTune perceptually optimized image compression. The image on the right has been compressed as much as possible while still ensuring that it is visually indistinguishable from the image on the left